Spallation Correction Erratum

This document provides some corrections to my thesis concerning the calculation for spallation survival in the CRIS instrument. Please refer to the following corrected information.

Background

In the calculation of the cosmic-ray intensities, we must correct for particles that suffer nuclear interactions in the SOFT detectors or the silicon wafers. This spallation correction depends on the total amount of material the particle traverses and the interaction lengths in each type of material in the CRIS instrument. Equation 3.2 (reproduced below) gives the probability that a particle with nuclear charge Z will survive without interacting in CRIS:

$$\epsilon_{spall}(Z,D) = \sum_{i=isotopes} w(Z,A_i)\, exp\left(-\frac{t_{Al}}{\Lambda_{Al}(A_i)} - \frac{t_{scint}}{\Lambda_{scint}(A_i)} - \frac{t_{Si}(D)}{\Lambda_{Si}(A_i)}\right) .$$

In this equation A_i are the atomic masses of the isotopes, t_{Al} and t_{scint} are the total thicknesses of the aluminum and scintillator material in the hodoscope, $t_{Si}(D)$ is the amount of silicon traversed if the particle stops in the middle depth of detector D (D = E2, E3, …,E8), and the $\Lambda(A_i)$ are the interaction lengths in each type of material. The thicknesses of the various detector elements are corrected for the incident angle. Each term in the summation is weighted by the isotopic fraction $w(Z,A_i)$. The interaction length in a target material with atomic mass A_T is calculated using Equation 3.3:

$$\Lambda(A_i) = \frac{A_T}{N_{Av}\sigma(A_i,A_T)} ,$$

where N_{Av} is Avogadro's number and $\sigma(A_i,A_T)$ is the total mass-changing interaction cross section.

Corrections

For the above calculation, the text correctly indicates that the Webber et al. (1990) cross section parameterization (Equations 3.4 and 3.5) is used to find $\sigma(A_i,A_T)$:

$$\sigma(A_i,A_T) = \pi r_o^2 \left(A_i^{1/3} + A_T^{1/3} - b\right)^2 ,$$
$$b = 1.36 - (0.018A_T) - (0.065A_i^{1/3}A_T^{1/3}) .$$

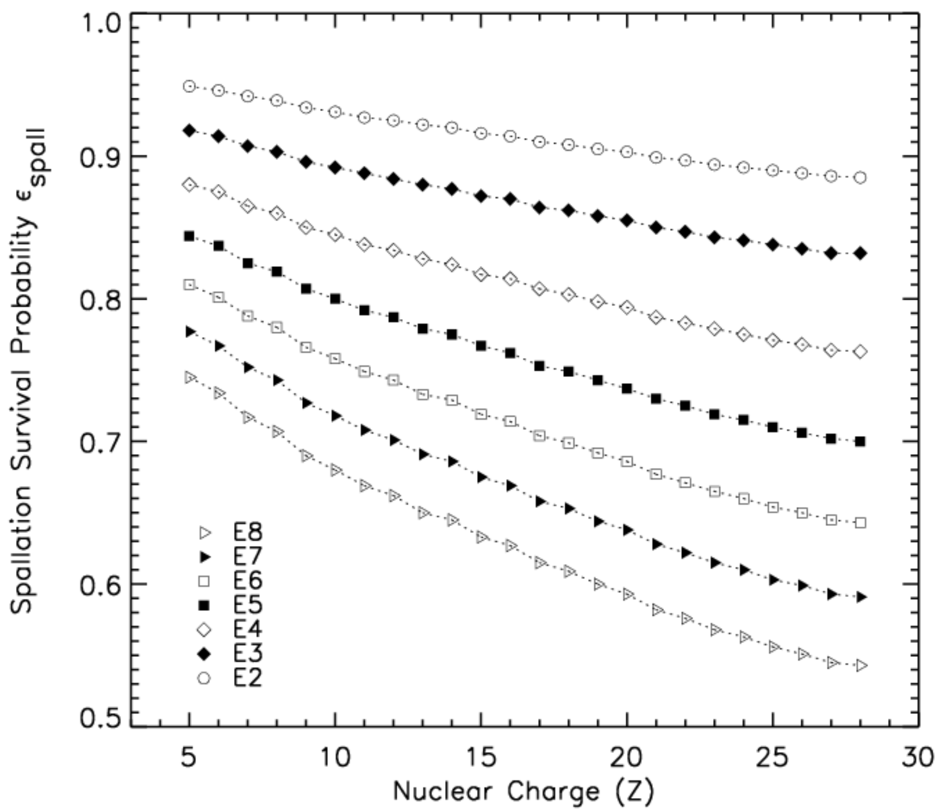
However, the value of r_o is incorrectly stated; it should have a value of 1.35 fm. This is the value given by Webber et al. (1990) and is the value used in our analysis. Incidentally, the value of 1.47 fm that was originally stated in the text is the value used for the Westfall et al. (1979) total mass-changing interaction cross section formula.

For hydrogen targets the Webber cross sections should also be multiplied by an energy-dependent correction factor given by Letaw et al. (1983):

$$f(\varepsilon) = 1 - 0.62e^{-\varepsilon/200}\sin(10.9\varepsilon^{-0.28}) .$$

The parameter ε is the incident energy given in units of MeV/nucleon. Since the hodoscope contains scintillator (C_8H_8), this factor should have been included in the determination of the middle term in the exponent of Equation 3.2 given at the beginning of this erratum. The interaction lengths in scintillator are about 2-5% larger when using Letaw, depending on the projectile mass and the incident energy. Since the hydrogen in the hodoscope represents a small percentage of the total material present in the instrument, this difference translates to very small changes of a few tenths of a percent in the spallation survival probabilities.

Finally, Figure 3.5 in this chapter is incorrect. The spallation survival probabilities shown there used the Westfall formula instead of the Webber formula. Since the Webber total interaction cross sections are used in our analysis, the following figure should instead be used.



References

Letaw, Silberberg, & Tsao, ApJS 51, pg 271 (1983)
Webber, Kish, & Shrier, Phys. Rev. C 41, pg 520 (1990)
Westfall et al., Phys. Rev. C 19, pg 1309 (1979)

SOFT Hodoscope Efficiency Erratum

This document provides an update concerning the SOFT hodoscope efficiencies. The parameterizations presented in my thesis are intended to update those efficiencies used in the work of George et al. (2009) and the data provided through the ACE website (http://www.srl.caltech.edu/ACE/). While the reported energy spectra in the thesis correctly used the new efficiencies described in Chapter 3.5, recent work intended for a future publication has revealed small errors in the parameterizations. This erratum describes the required changes to the formulae; all future work will incorporate the parameterizations given below.

Background

The SOFT hodoscope is used to determine the trajectories of cosmic rays as they enter the CRIS instrument. Some nuclei, most significantly those species with low nuclear charge that produce the weakest signals, are not properly detected by this system due to signal attenuation in the fibers or weak signals produced when the nuclei pass through the acrylic cladding surrounding the fibers. This leads to the failure to determine a trajectory and therefore the event is rejected from the analysis.

The hodoscope efficiencies used in this work were calculated for each of the four telescopes by de Nolfo (2006, 2010) and are parameterized by the energy loss *dE/dx* in silicon at the top of the instrument. The following equation is used to parameterize the efficiencies, with Table 3.3 in Chapter 3 providing the values of the five fit coefficients given by A_0 through A_4.

$$\epsilon_{SOFT} = A_0 - A_1 e^{-(dE/dx)/A_2} - A_3 e^{-(dE/dx)/A_4}$$

Corrections

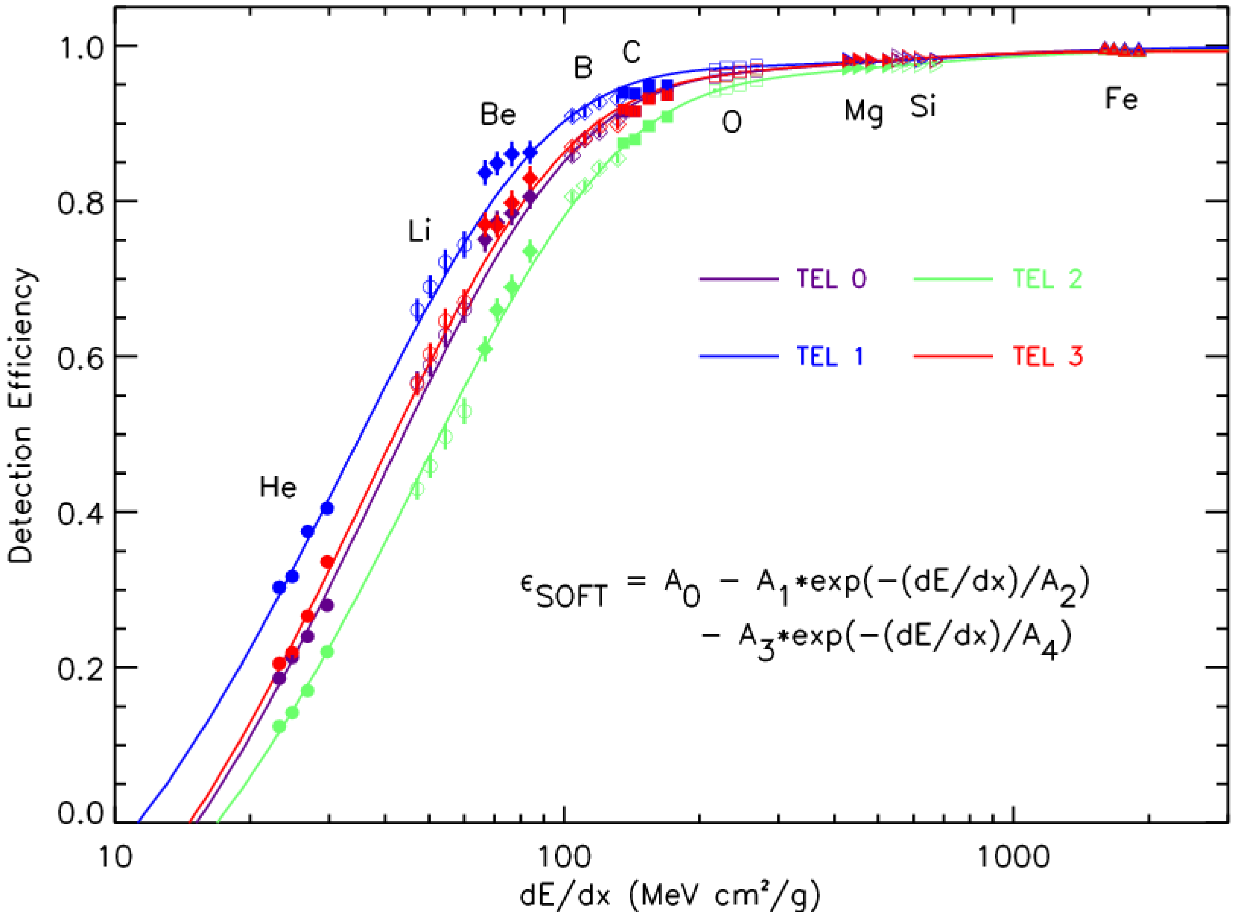
The fit parameters for the four telescope parameterizations were determined using efficiency measurements for helium, lithium, beryllium, boron, carbon, oxygen, and iron nuclei stopping in detectors E5-E8. Some of these data were incorrectly transcribed from their original sources, though the resulting equations still fit the data well at most energies. Additionally, data for magnesium and silicon stopping in detectors E5-E8 have been added to the fit.

With these additions and corrections, new parameterizations have been determined and are given in the following table. The figure at the end of this erratum plots the new detection efficiencies as a function of energy loss; it may be compared to the outdated parameterizations shown in Figure 3.6 in Chapter 3.

New Parameterizations for the SOFT Hodoscope Efficiencies

Telescope	A_0	A_1	A_2	A_3	A_4
0	0.996	1.407	38.68	0.049	442.3
1	0.998	1.359	33.00	0.034	741.4
2	0.995	1.335	47.91	0.059	505.2
3	0.993	1.410	36.36	0.054	336.3

These new parameterizations will have a very small effect on the average efficiencies for the whole instrument, and therefore the calculated energy spectra. For low-Z species such as boron and carbon, the efficiencies change by less than 0.3%; these differences become negligible for all heavier species. This thesis work does not consider helium, lithium, and beryllium so these efficiencies will not be discussed here.



References

de Nolfo, G. A., et al. Advances in Space Research 38, 1558, 2006.
de Nolfo, G. A. *CRIS SOFT efficiencies parameterized by telescope*, private communication, 2010.
George, J. S., et al. ApJ 698, 1666, 2009.